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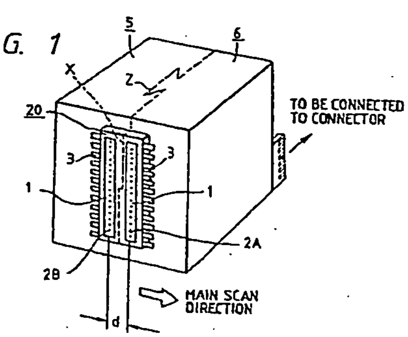
(54) Recording head cartridge and recording apparatus using the same.

(57) This invention is a recording head cartridge which includes a plurality of inks having a density difference for an ink of one color, includes recording heads on a single substrate or in an adjacent aligned state, and integrates ink tanks for the plurality of inks, so as to reliably perform gradation recording while achieving a simple control circuit, and improvement in operability upon replacement. This invention also provides a structure in which ink tanks in the cartridge are integrated to determine a light/depth printing order, and have different volumes so as to improve advantages of replacement.

FIG. 1



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Recording Head Cartridge and Recording Apparatus Using the Same

BACKGROUND OF THE INVENTION:

[Field of the Invention]

The present invention relates to a recording head cartridge which integrates an ink-jet recording head and an ink storing unit for storing an ink to be supplied to the recording head.

[Description of the Related Art]

Recording apparatuses ordinarily used in printers or facsimile systems perform recording on the basis of binary recording data indicating whether or not a dot is present on a pixel. When an original expressed by many density levels such as a photography, a print, a painting, or the like is to be reproduced, a difference between the densities of dots forming a recording image becomes conspicuous, and the image exhibits graininess. In particular, in a highlight portion, this tendency is considerable.

For this reason, an ink-jet recording apparatus of a density multi-value recording system using light and deep inks, and capable of converting the densities of dots to be jetted to a recording medium into multi-values is proposed. According to the density multi-value recording system, when binary data expressing a density is merely converted to three-value data, gradation of a recording image, in particular, gradation of a highlight portion is improved, and graininess caused by dots can be eliminated. As a result, image quality of a recording image can be improved.

In an ink-jet recording apparatus, a proposal for solving a problem caused by an arrangement wherein a recording head for discharging an ink, and an ink storing unit (to be simply referred to as an ink tank hereinafter) are separately arranged has been made. More specifically, since an ink tube or the like is used to supply an ink from the ink tank to the recording head, dust or air enters through connecting portions or the like of this tube, and becomes dust or bubbles in an ink, thus posing a problem of impaired stability of ink discharge. In addition, a cumbersome operation is required to connect a tube when the ink tank or the recording head is replaced, and an operation for preventing entrance of bubbles upon replacement is not easy. Thus, in order to prevent these problems, a recording head cartridge which integrates the recording head and the ink tank has been proposed.

The recording head cartridge has also been proposed in view of the fact that latest recording heads can be mass-produced with low cost by the same process as the semiconductor device manufacturing process. More specifically, with this integrated structure, when an ink to be stored is used up, an old cartridge is replaced with a new recording head cartridge integrated with a recording head, and the old recording head and ink tank can be disposed.

In the density multi-value recording system using the above-mentioned ink-jet recording apparatus, the dot size of the light and deep inks, the pitches of light and deep ink dots, the dye densities of the light and deep inks, and the like are optimized, thereby decreasing a dye density of the light ink as much as possible. A dye density of the deep ink is increased to increase an optical density, and a density jump occurring at an interface between the light and deep inks is prevented while improving gradation.

As a recording system which can satisfy the above-mentioned requirements, a method wherein an ink having a higher dye density is jetted first, the dye density is sequentially lowered, and finally, an ink having a lowest dye density is jetted is known. With this method, a high-gradation, high-resolution, and high-quality image free from graininess can be obtained.

However, when full-color recording is performed by the above-mentioned recording head cartridge arrangement, two types of, i.e., light and deep ink cartridges must be prepared for each of cyan (C), magenta (M), yellow (Y), and black (B) inks, and a carriage which carries a total of eight cartridges to perform scanning movement for recording becomes large in size.

Since recording head cartridges for light and deep inks cannot be integrated with each other, when light and deep ink cartridges of the same color are simultaneously replaced (one ink is rarely used alone), a cumbersome operation therefore is required.

Since an interval between an orifice array for discharging a light ink and that for discharging a deep ink inevitably becomes large, a long period of time is required after the deep ink is discharged until the light ink is discharged. In order to perform synchronization between recording data sent from a host apparatus or the

like and ink discharge during this period of time, the capacity of a buffer memory for temporarily storing these data must be increased, and cost of the entire apparatus is increased.

Since the interval between the orifice arrays is large, when light and deep inks are jetted to overlap each other, the light ink often overlaps the deep ink after the deep ink is absorbed. In this case, graininess caused by deep ink dots appears, and high image quality of the density multi-value recording system is impaired.

Furthermore, as for the interval between the orifice arrays, since the light and deep ink cartridges are not integrated, as described above, the interval therebetween is varied upon replacement of cartridges, and this variation adversely influences image quality of a recorded image.

When such recording is performed, a light ink is uses as much as possible to obtain a high-gradation, high-resolution image free from graininess, as is known. Therefore, when high image quality of the density multi-value recording system and a cartridge structure of a recording head and an ink tank in consideration of operability are realized at the same time, a frequency of replacement of a cartridge for a light ink which is used more than a deep ink is increased.

Upon replacement of the light ink cartridge, the deep ink cartridge must also be replaced (the deep ink is rarely used alone), resulting in waste of the cartridge.

In order to avoid such waste, a cartridge may have a light ink tank having an increased tank volume. With this structure, however, a difference in tank shape causes a difference in the distance between the heads (the distance between the discharge ports) of the light and deep inks, and the capacity of a buffer memory for performing synchronization between a supply timing of recording data and an ink discharge timing must be further increased, thus posing a new problem.

When a volume difference is compensated for by a flexible ink tank, movement precision of the cartridges upon recording cannot be maintained, and this structure impairs an easy handling feature of the cartridge.

SUMMARY OF THE INVENTION:

The present invention has been made in consideration of the above-mentioned problems, and has as its object to provide a recording head cartridge wherein light and deep ink cartridges are integrated to shorten distances between corresponding orifices, thereby providing a recording head more suitable for a density multi-value recording system, and the overall size of the recording head is reduced to improve operability upon replacement.

It is another object of the present invention to provide a recording apparatus wherein a plurality of recording head cartridges for recording inks having different densities on a recording medium to overlap each other upon movement relative to the recording medium, each of which comprises a plurality of recording heads, having discharge ports, for discharging, from the discharge ports, inks having different densities for the same ink color, and a plurality of ink storing units, integrally arranged in correspondence with the plurality of recording heads, for storing inks to be discharged from the corresponding recording heads, are integrally arranged, and are aligned according to an overlapping order of inks.

According to the above arrangement of the recording apparatus, inks to be jetted on the recording medium can overlap each other in the order of higher ink densities, and a distances between discharge ports for discharging inks having different densities can be shortened.

Therefore, a discharge interval of inks having different densities can be decreased.

It is still another object of the present invention to provide a recording head in which recording head cartridges corresponding to inks having different densities are integrated, and the volumes of tanks for inks having lower densities are increased, so that replacement of cartridges without any waste and improvement of operability upon replacement can be realized, and a distance between discharge ports for discharging inks having different densities can be decreased.

For this purpose, according to the present invention, a plurality of recording head cartridges, for performing recording using inks having different densities, each of which comprises a plurality of recording heads for discharging inks having different densities, and ink storing units, integrally arranged in correspondence with the plurality of recording heads, for respectively storing inks to be discharged from the corresponding recording heads, are integrally arranged, and the volumes of the ink storing units are determined in accordance with amounts of use of inks having different densities.

According to the above arrangement, a plurality of recording head cartridges corresponding to inks having different densities are integrally arranged, and the volumes of the ink storing units are determined in accordance with amounts of use of inks having different densities, so that waste of an ink can be prevented

upon replacement of the recording head cartridge, and a discharge interval of inks having different densities can be decreased.

BRIEF DESCRIPTION OF THE DRAWINGS:

Fig. 1 is a perspective view of an ink-jet recording head cartridge according to an embodiment of the present invention;

Fig. 2 is a perspective view for explaining a method of integrally arranging ink tanks shown in Fig. 1;

Fig. 3 is a perspective view showing a main part of a recording apparatus to which the recording head cartridge shown in Fig. 1 is applied;

Fig. 4 is a block diagram of an image data processing circuit according to an embodiment of the present invention;

Fig. 5 is a graph showing the principle of a light/depth distribution table shown in Fig. 4;

Fig. 6 is a perspective view showing a main part of a recording apparatus according to another embodiment of the present invention;

Fig. 7 is a graph showing the principle of a light/depth distribution table in the embodiment shown in Fig. 6;

Figs. 8A and 8B are side sectional views for explaining a difference in image quality depending on overlapping states of inks;

Fig. 9 is a perspective view of an ink-jet recording head cartridge according to another embodiment of the present invention;

Fig. 10 is a perspective view for explaining a method of integrally arranging an ink tank shown in Fig. 9;

Fig. 11 is a perspective view showing a main part of a recording apparatus to which the recording head cartridge shown in Fig. 9 is applied;

Fig. 12 is a graph showing the principle of a light/depth distribution table shown in Fig. 4 for the cartridge shown in Fig. 9 which is arranged in correspondence with a ratio of ink discharge;

Fig. 13 is a perspective view showing a main part of a recording apparatus according to still another embodiment of the present invention; and

Fig. 14 is a graph showing the principle of a light/depth distribution table in the embodiment shown in Fig. 13 which is arranged in correspondence with a ratio of ink discharge.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

An embodiment of the present invention will be described below with reference to the accompanying drawings.

Fig. 1 is a perspective view of a recording head cartridge according to an embodiment of the present invention. In Fig. 1, a plurality of orifices 2 (2A and 2B) are formed as discharge ports for discharging liquid droplet or droplets on orifice plates 1. An ink tank 5 stores an ink of light color or light ink, and an ink tank 6 stores an ink of deep color or deep ink. The light and deep ink tanks 5 and 6 are arranged adjacent to each other.

Each orifice 2 has an ink chamber communicating with it. An electric-heat conversion member for generating heat energy used to discharge an ink is disposed in the ink chamber. A common chamber for commonly supplying an ink to the ink chambers is arranged on a side of the ink chambers opposite to a side communicating with the orifices 2. The common chamber is supplied with an ink through a predetermined supply path from the corresponding neighboring ink tank. Connector pins 3 supply electrical signals according to recording data to the corresponding electric-heat conversion members.

In this embodiment, the light and deep ink tanks 5 and 6 are integrated by a slidable fitting system (by means of a trapezoidal recess portion Z0 of the tank 5 and a trapezoidal projecting portion Z1 of the tank 6). An integrally formed recording head 20 on which the 128 orifices 2A for discharging the deep ink and the 128 orifices 2B for discharging the light ink are arrayed in a sub scan direction is mounted on the integrated ink tanks 5 and 6. Although not shown, the above-mentioned common chambers and the supply paths from the ink tanks are separately arranged in correspondence with the light and deep inks

With the above arrangement, a distance d between corresponding orifices for the light and deep inks in a main scan direction can be shortened, and the recording head cartridge itself can be rendered compact. Furthermore, a variation in distance d upon replacement of the cartridge can be suppressed within a range of a manufacturing allowance.

In this embodiment, recording head units (orifice plates) 1 are respectively aligned and fixed to the tanks 5 and 6. For this reason, when a junction portion Z (Fig 1) is formed upon engagement between the trapezoidal recess and projecting portions Z0 and Z1, stepped portions are brought into slide contact with each other, as indicated by a junction portion X (Fig. 1), and the recording head units 1 are integrated, so that alignment can be performed very close to each other.

Note that in the recording head units 1, light and deep ink chambers and ink supply pipes may be formed on a single substrate, and are inserted in and adhered to holes of the corresponding ink tanks. Thus, various forming methods of the recording head units 1 may be employed.

Fig. 3 shows an embodiment wherein the recording head cartridge shown in Fig. 1 is applied to each of C, M, Y, and K color inks to constitute recording heads corresponding to full-color recording. As shown in Fig. 3, recording head cartridges each of which integrates light and deep ink tanks in units of color inks are carried on a carriage 7. The carriage 7 is moved in the main scanning direction along a guide shaft 8.

The recording head in each cartridge produces bubbles by heat energy generated by the above-mentioned electric-heat conversion members, and discharges ink droplets according to a change in state of an ink upon a change in bubbles. The orifice diameter of this recording head is 30 µm. Thus, the diameter of a droplet to be discharged is 30 µm, and a dot diameter formed by jetting the droplet on a recording medium is 100 µm. A drive frequency of the recording head is 2.5 kHz, and an image recording density is 400 dpi.

Furthermore, the dye densities of color inks are set such that Y (light...0.7%, deep...2.0%), C (light...0.7%, deep...2.5%), M (light...0.6%, deep...2.5%), and K (light...1.0%, deep...3.5%). The order of jetting inks on one pixel is deep → light. In addition, the order of jetting the color inks is C → M → Y → K.

In this embodiment, as described above, recording is performed such that a deep ink is discharged first, and then, a light ink is discharged. If the discharge order is reversed, a deep ink dot having a high dye density is spread to overlap a light ink dot having a low dye density, as shown in Fig. 8B, and it appears that a large deep ink dot is jetted on a recording medium. As a result, graininess is undesirably emphasized. Thus, in this embodiment, as shown in Fig. 8A, a deep ink is discharged first, and then, a light ink is discharged to overlap the deep ink, thus decreasing graininess.

In addition, even in the recording system of this embodiment, if a discharge interval between the light and deep inks is large, as described above, graininess caused by deep ink dots is emphasized. In this case, the light and deep ink recording head cartridges are integrated to shorten a distance between orifices of the recording heads for the light and deep inks, thus avoiding emphasized graininess.

This phenomenon varies depending on distribution tables and binarization schemes. In particular, in a region extending from a highlight portion to a middle density portion and requiring high gradation, an effect of this embodiment can be remarkable.

This effect becomes more remarkable as the discharge interval of the light and deep inks is shorter. In this case, the next light ink is jetted preferably on a recording medium such as paper before the previously printed deep ink is absorbed by the paper.

This control is reliably performed by a drive controller (not shown) of an ink-jet recording apparatus.

Processing executed when the recording apparatus using the recording head cartridges having the above structure converts color video signals or electrical signals from an image scanner into density multi-value signals, and outputs the density multi-value signals will be described below with reference to Fig. 4.

Fig. 4 is a block diagram showing an arrangement for light/depth distribution processing and binarization processing, which is arranged in correspondence with each of color inks Y, M, C, and K. An image processing circuit 41 executes shading correction of RGB signals from a color image scanner or the like, and then executes input masking, logarithmic conversion, and output masking operations, thereby outputting 8-bit mono-color data corresponding to the ink color C. Note that mono-color data for other ink colors, M, Y, and K are output from the similar circuits.

The outputs mono-color data is distributed into light ink data (C') and deep ink data (C'') by a light/depth distribution table 42. Thereafter, the light and deep ink data are respectively binarized by corresponding binary circuits ((4 x 4) x 2 Bayer dither matrices) to be supplied to the recording heads as 1-bit ON/OFF data. In this embodiment, the binary circuit employs a dither method but may employ various other methods, e.g., an error scattering method.

A method of forming the light/depth distribution table shown in Fig. 4 will be described below. Seventeen density levels are set for each of the light and deep inks, and patches of all combinations (17 x 17 sets of light inks overlapping deep inks are formed using these inks. Optical densities (OD values) of these patches are then measured by a color analyzer CA-35 (available from Murakami Shikisai-sha). The relationships between combinations of the light and deep inks and optical densities are obtained from the measurement results, and a relationship in which an optical density as output data linearly changes

according to a change in mono-color data as input data shown in Fig. 4 is selected from the obtained relationships. Upon this selection, combinations of the light and deep inks corresponding to input data can be determined, and are formed as a distribution table.

Fig. 5 shows the principle of the distribution table obtained in this manner. Fig. 5 shows the distribution table for the ink color C. In Fig. 5, output data for the light ink as a function of input data is indicated by a solid line, and output data for the deep ink as a function of input data is indicated by an alternate long and short dashed line. As can be seen from this graph, only the light ink is used up to input data = 150, and when the input data exceeds 150, the light and deep inks are combined.

When an image of a color picture (silver chloride) was copied using the above-mentioned arrangement, an image free from graininess and having considerably improved gradation on a highlight portion such as a skin portion as compared to a normal binary image could be obtained.

Fig. 6 shows an ink-jet recording apparatus according to another embodiment of the present invention. This apparatus performs four-value recording of a light ink (0.5%), a medium ink (1.0%), and a deep ink (0.3%) using only a black ink.

In Fig. 6, a light ink cartridge 5, a medium (density) ink cartridge 9, and a deep ink cartridge 6 are integrally arranged so that an ink discharge order from these cartridges is set to be deep → medium → light. Recording head units indicated by a broken line in Fig. 6 have a shorter distance between orifice arrays than that of a conventional apparatus, as in the embodiment shown in Fig. 1.

In this structure, Table 1 below summarizes examination results of image quality and graininess by changing the ink discharge order of the deep ink (0.3%), the medium ink (1.0% or 1.5%), and the light ink (0.5%). In Table 1, signs show the following fact respectively. ◎ shows "very good", ○ "good", Δ "not good, but not bad" and x "bad".

Table 1

Discharge Order			Evaluation	
1	2	3	Image Quality	Graininess
0.5%	1.5%	3.0%	Δ	X
3.0%	0.5%	1.5%	○	X
0.5%	3.0%	1.5%	○	Δ
1.0%	3.0%	0.5%	○	○
3.0%	0.5%	1.0%	○	◎
3.0%	1.0%	0.5%	◎	◎

As can be understood from Table 1, when a dye density difference is smaller than 1% like the second and third inks, as shown in two lowest rows in Table 1, even if the discharge order is changed, image quality and graininess are not changed very much. However, as can also be understood from Table 1, when the discharge order of inks having a density difference of 1% or more is changed, evaluations of image quality and graininess are considerably changed.

Therefore, when inks having a dye density difference of 1% or more are jetted, if the order of this embodiment is employed, a noticeable difference in image quality and the like can be obtained as compared to a case in which such a specific order is not employed.

A light/depth distribution table of this embodiment is created in the same manner as in the above embodiment. This table is shown in Fig. 7.

In this embodiment, recording head cartridges having the same orifice diameters are used. However, recording head cartridges having different orifice diameters may be combined.

All the ink colors do not always require light and deep inks. The number of kinds of inks may be increased/decreased according to required image quality.

Furthermore, the recording head used in the embodiments discharges an ink upon production of bubbles by heat energy. However, the present invention is not limited to this. For example, the present invention may be applied to a recording head for discharging an ink using, e.g., a piezoelectric element.

As can be seen from the above description, according to the present invention, inks to be jetted on a recording medium can overlap each other in the order of higher ink densities, and a distance between discharge ports for discharging inks having different densities can be shortened.

Thus, a discharge interval of inks having different densities can be shortened.

As a result, a high-resolution, high-gradation image free from graininess by the density multi-value recording system can be recorded.

Since the discharge interval is shortened, the capacity of the buffer memory can be decreased, and total cost of the apparatus can be reduced.

Since the cartridges are integrated, a variation is discharge portion precision can be reduced, and handling property of the cartridges can be improved.

Another embodiment of the present invention will be described below with reference to Figs. 9 to 14. Since the embodiment described below has the same arrangement as described above, only differences will be described.

Fig. 9 is a perspective view of a recording head cartridge according to another embodiment of the present invention.

In this embodiment, light and deep ink tanks 5 and 6 are integrated by a slidable fitting system, as shown in Fig. 10. The shapes of the ink tanks are determined so that the volume of the light ink tank 5 is 2.5 times that of the deep ink tank 6. Recording heads 1 of this embodiment are mounted on and fixed to the corresponding tanks through ink supply pipes (not shown) after the tanks are assembled. More specifically, the recording head units 1 are an integrated component in which orifices 2A and 2B are formed on the same substrate.

As has been described above with reference to Fig. 1, a distance d between corresponding ink orifices can be shortened in the main scan direction. The recording head cartridge itself can be rendered compact. In addition, a variation in distance d caused upon replacement of cartridges can be suppressed within the range of a manufacturing allowance.

Fig. 11 shows an embodiment wherein the recording head cartridge shown in Fig. 9 is applied to each of C, M, Y, and K color inks to constitute recording heads corresponding to full-color recording. As shown in Fig. 11, recording head cartridges each of which integrates light and deep ink tanks in units of color inks are carried on a carriage 7, and are used in unidirectional printing. The inks and the recording system are the same as those in the embodiment shown in Fig. 1. A ratio of inks discharge (%) based on the block diagram shown in Fig. 4 will be described below with reference to Fig. 12.

Fig. 12 shows the distribution table for the ink color C. In Fig. 12, output data for the light ink as a function of input data is indicated by a solid line, and output data for the deep ink as a function of input data is indicated by an alternate long and short dashed line. As can be seen from this graph, only the light ink is used up to input data = 150, and when the input data exceeds 150, the light and deep inks are combined. It can also be understood that the amount of use of the light ink is more than that of the deep ink, and its ratio is about 1 : 2.4.

When an image of a color picture (silver chloride) was copied using the above-mentioned arrangement, an image free from graininess and having considerably improved gradation on a highlight portion such as a skin portion as compared to a normal binary image could be obtained.

When an ink consumption durability test (about 250 sheets) using a color chart of the Society of Image Electronics No. 11 was conducted using only a cyan ink, the remaining amount of a light ink was about 0.87 cc when a deep cyan ink was used up. In consideration of the fact that the ink amount in the light ink tanks was initially 30.0 cc, the effect of the arrangement in which the volume of the light ink tank is set to be about 2.4 times that of the deep ink tank can be obtained as expected from the table shown in Fig. 12.

Fig. 13 shows an ink-jet recording apparatus according to another embodiment of the embodiment shown in Fig. 9 according to the present invention. This apparatus performs four-value recording of a light ink (0.5%), a medium ink (1.0%), and a deep ink (0.3%) using only a black ink.

In Fig. 6, a light ink cartridge 5 (rectangular prism), a medium (density) ink cartridge 9 (rectangular prism having a recess portion), and a deep ink cartridge 6 (having a shape engaged with the cartridge 9 to define a rectangular prism together with the cartridge 9) are integrally arranged so that an ink discharge order from these cartridges is set to be deep → medium → light. Recording head units indicated by a broken line in Fig. 6 have a shorter distance between orifice arrays than that of a conventional apparatus, as in the embodiment shown in Fig. 1.

A distribution table is created by the same method as in the above embodiment, i.e., 17 x 17 density levels for light and medium inks, and 17 x 17 density levels for medium and deep inks. Fig. 14 shows this distribution table.

As can be seen from this graph, the amounts of use of the light and medium inks are large, and that of the deep ink is small.

In the apparatus shown in Fig. 13, the volumes of deep, medium, and light ink tanks of the cartridge were set to be 10 cc, 20 cc, and 25 cc, respectively, so that the volume of the ink tank having the maximum

dye density was minimum, and recording according to a predetermined chart was performed. As a result, differences in residual ink amounts of the respective densities were small.

However, different results are obtained for a chart having a wide highlight portion, and for an image having a wide solid-black portion. When an image includes a wide highlight portion, a consumption of a light ink is increased. When an image includes a wide solid-black portion, a consumption of a deep ink is increased.

In this manner, when four-value recording using deep, medium, and light inks is performed, images which satisfy both resolution and gradation, i.e., a character to a landscape image including wide halftone portions, can be obtained.

As can be apparent from the above description, according to the embodiment of the present invention, a plurality of recording head cartridges corresponding to inks having different densities are integrally arranged, and the volumes of the ink storing units are determined in accordance with amounts of use of inks having different densities, so that waste of an ink can be prevented upon replacement of the recording head cartridge, and a discharge interval of inks having different densities can be decreased.

As a result, operability of the cartridge can be improved, and recording with good image quality can be performed.

The present invention can provide an excellent effect that a density balance can be stabilized with high-gradation by the advantage of its dot forming precision, especially, in a bubble-jet recording head and recording apparatus among ink-jet recording systems.

As for the typical arrangement and principle of the bubble-jet recording system, the basic principles disclosed in, e.g., U.S. Patent Nos. 4,723,129 and 4,740,796 are preferably used. This system can be applied to both the on-demand type and the continuous type. In particular, this system can be advantageously applied to the on-demand type for the following reason. That is, at least one drive signal corresponding to recording information and giving an abrupt temperature rise exceeding nuclear boiling is applied to an electric-heat conversion member arranged in correspondence with a sheet for holding a liquid (ink) or a liquid path to cause the electric-heat conversion member to generate heat energy, thereby causing a heat application surface of a recording head to cause film boiling. A bubble in the liquid (ink) can be consequently formed in a one-to-one correspondence with this drive signal. Upon growth and compression of this bubble, a liquid (ink) is discharged through a discharge opening, thereby forming at least one droplet. If this drive signal consists of pulses, growth and compression of bubbles can be quickly and appropriately performed, and discharge of a liquid (ink) with a particularly short response time can be preferably achieved. As this drive pulse signals, signals described in U.S Patent Nos. 4,463,359 and 4,345,262 are suitable. When a condition described in U.S. Patent No. 4,313,124 associated with a temperature rise rate of the heat application surface is adopted, further excellent recording is allowed.

As the structure of the recording head, the present invention incorporates structures using those described in U.S. Patent Nos. 4,558,333 and 4,59,600 which disclose structures in which a heat application portion is arranged on a bending region, as well as the structure as a combination of discharge ports, liquid paths, and electric-heat conversion members disclosed in the above-mentioned specifications. In addition, the present invention can be effectively applied to a structure based on Japanese Patent Laid-Open No. 59-123670 which discloses a structure in which a common slit serves as a discharge portion of a plurality of electric-heat conversion members, and to a structure based on Japanese Patent Laid-Open No. 59-138461 which discloses a structure in which an opening for absorbing a pressure wave of heat energy is arranged in correspondence with a discharge portion.

Furthermore, the present invention can also be applied to a full-line type recording head having a length corresponding to a width of a maximum recording medium which can be recorded by a recording apparatus. In this case, the present invention may be applied to a structure in which the length is satisfied by a combination of a plurality of recording heads described in the above-mentioned specifications, or a structure in which the length is satisfied by a single recording head. In these structures, the present invention can further effectively provide the above-mentioned effect.

It is preferable that a recovery means and an auxiliary means are added to a recording head as a component of the recording apparatus of the present invention since the effect of the present invention can be further stabilized. More specifically, a capping means, a cleaning means, a compression or suction means, a sub heating means comprising electric-heat conversion members, or other heating elements, or a combination of these members, and a means for executing an auxiliary discharge mode for performing discharge different from recording are effectively arranged to the recording head to allow stable recording.

Furthermore, the present invention is not limited to a recording mode using principal colors such as black as a recording mode of the recording apparatus. For example, the present invention can be effectively applied to an apparatus which comprises at least one of a multi-color mode of different colors and a full-

color mode by mixing colors by using an integrated recording head or a combination of a plurality of recording heads.

This invention is a recording head cartridge which includes a plurality of inks having a density difference for an ink of one color, includes recording heads on a single substrate or in an adjacent aligned state, and integrates ink tanks for the plurality of inks, so as to reliably perform gradation recording while achieving a simple control circuit, and improvement in operability upon replacement. This invention also provides a structure in which ink tanks in the cartridge are integrated to determine a light/depth printing order, and having different volumes so as to improve advantages of replacement.

Claims

1. An integrated recording cartridge head comprising a plurality of recording head, having discharge ports, for discharging, from said discharge ports, inks having different densities for the same color, and ink storing units, integrally arranged in correspondence with said plurality of recording heads, for storing inks to be discharged from the corresponding recording heads, wherein upon movement relative to a recording medium, the inks having different densities are recorded on said recording medium to overlap each other.

2. A cartridge according to claim 1, wherein each of said recording heads comprises electric-heat conversion members for generating heat energy in correspondence with the discharge ports.

3. An ink-jet recording apparatus comprising a recording head cartridge which integrates a plurality of recording head, having discharge ports, for discharging, from said discharge ports, inks having different densities for the same color, and ink storing units, integrally arranged in correspondence with said plurality of recording heads, for storing inks to be discharged from the corresponding recording heads, and has a mode in which a deep ink is printed first, and a light ink is printed to overlap the deep ink.

4. An apparatus according to claim 3, wherein the light ink is jetted before the deep ink is fixed to a recording medium.

5. A recording head cartridge for performing recording on a recording medium using inks having different densities, which comprises a plurality of recording head, having discharge ports, for discharging, from said discharge ports, inks having different densities for the same color, and ink storing units, integrally arranged in correspondence with said plurality of recording heads, for storing inks to be discharged from the corresponding recording heads,
wherein a plurality of said recording head cartridges are integrally arranged, and volumes of said ink storing units are determined in accordance with amounts of use of the inks having different densities.

6. A cartridge according to claim 5, wherein the volumes of said ink storing units are determined so that the volume of the ink storing unit corresponding to a minimum density is maximum.

7. A cartridge according to claim 5, wherein as the density is lower, the volumes of said ink storing units become larger.

8. A cartridge according to claim 5, wherein each of said recording heads comprises electric-heat conversion members for generating heat energy in correspondence with the discharge ports.

FIG. 1

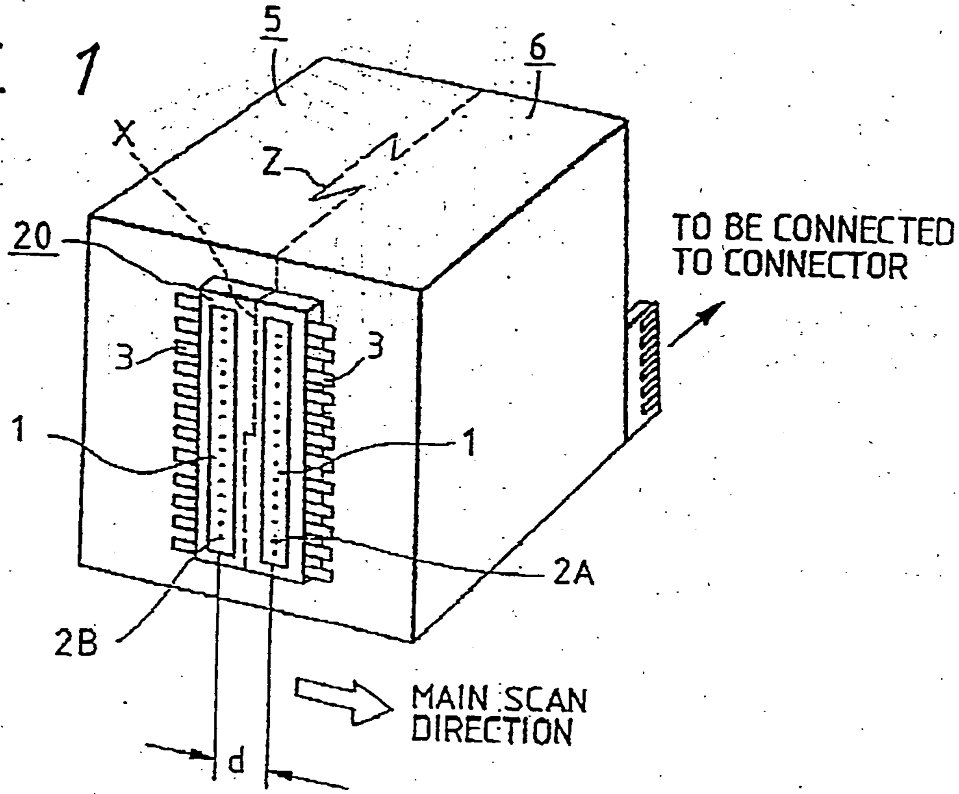

5
6
X
Z
20
3
3
1
1
2A
2B
TO BE CONNECTED TO CONNECTOR
MAIN SCAN DIRECTION
d

FIG. 2

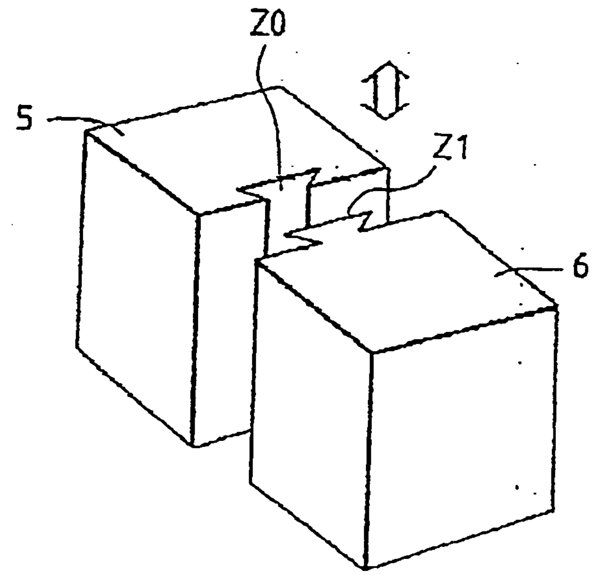

Z0
5
Z1
6

FIG. 3

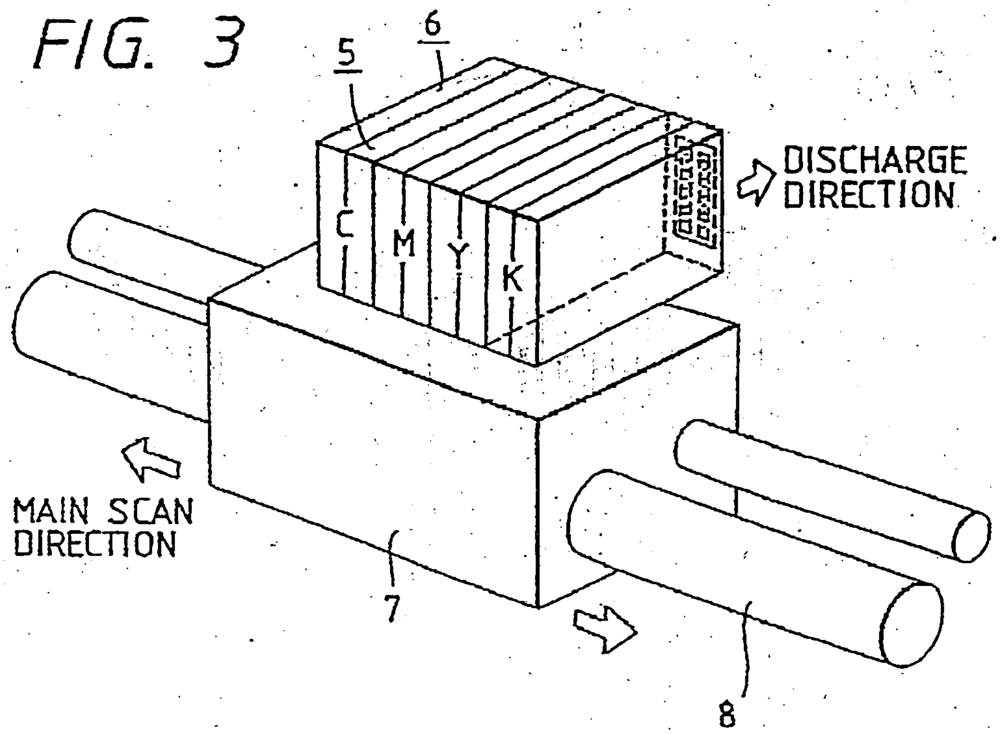

6
5
C
M
Y
K
DISCHARGE DIRECTION
MAIN SCAN DIRECTION
7
8

FIG. 6

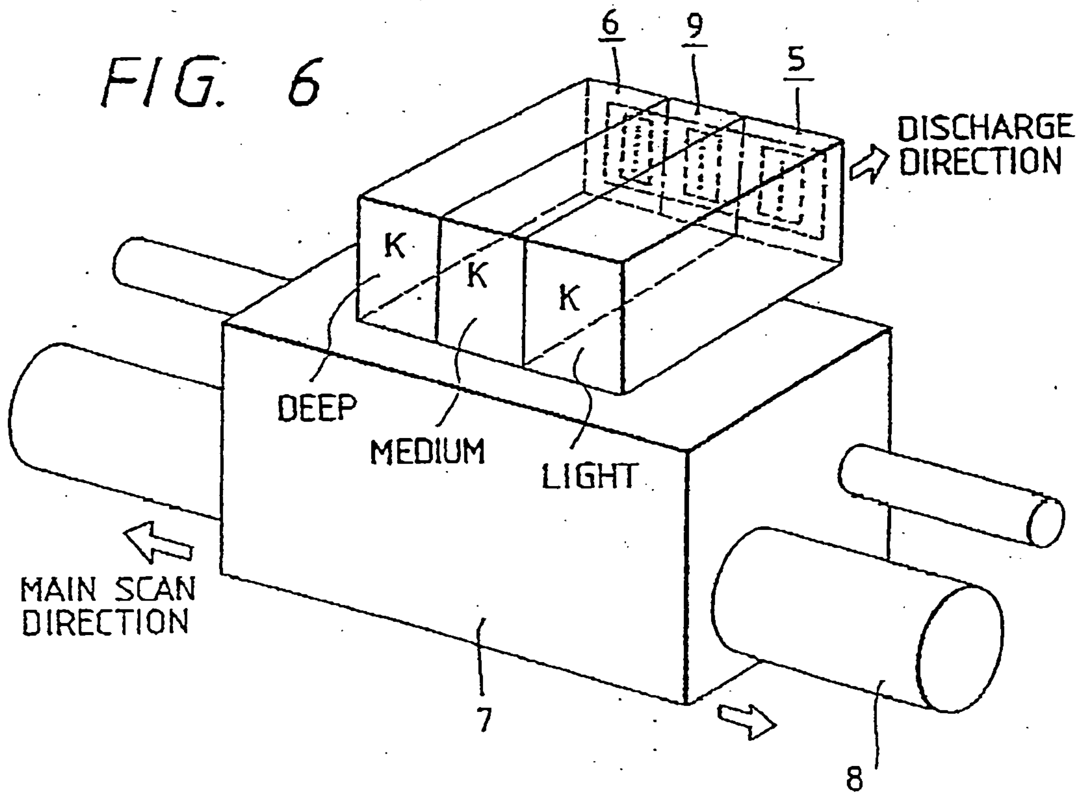

6
9
5
DISCHARGE DIRECTION
K
K
K
DEEP
MEDIUM
LIGHT
MAIN SCAN DIRECTION
7
8

FIG. 4

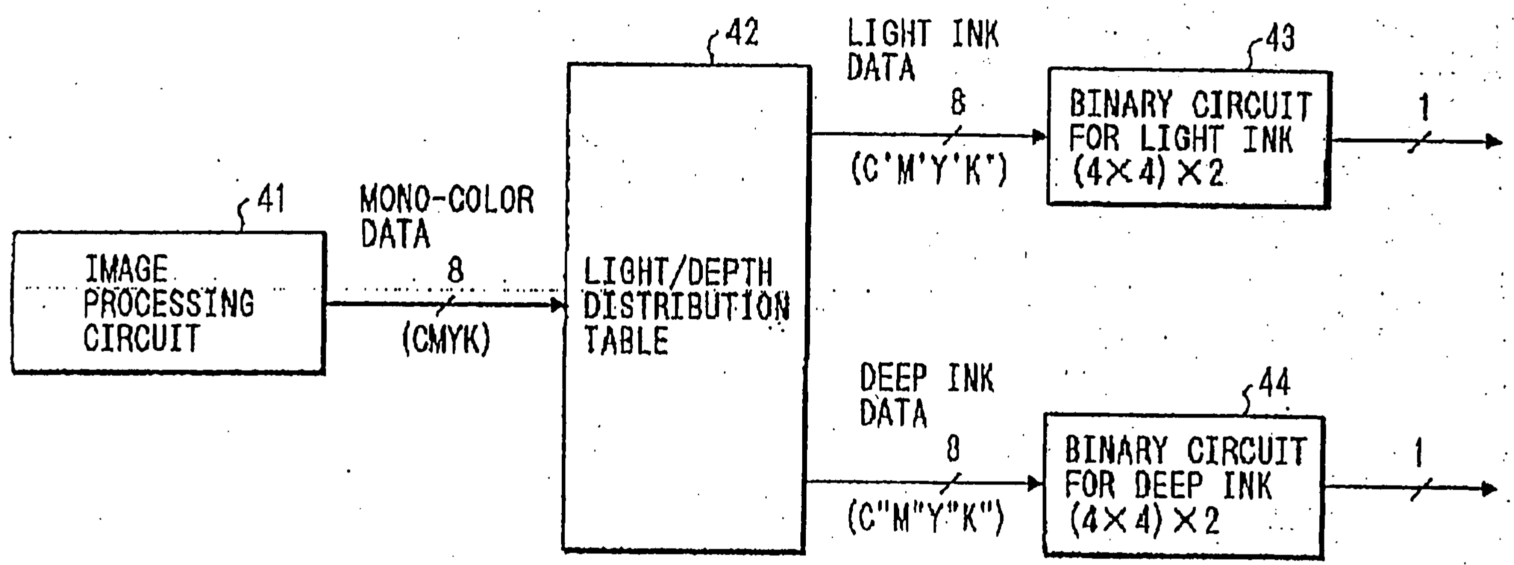

41
IMAGE PROCESSING CIRCUIT
MONO-COLOR DATA
8
(CMYK)
42
LIGHT/DEPTH DISTRIBUTION TABLE
LIGHT INK DATA
8
(C'M'Y'K')
43
BINARY CIRCUIT FOR LIGHT INK (4×4)×2
1
DEEP INK DATA
8
(C"M"Y"K")
44
BINARY CIRCUIT FOR DEEP INK (4×4)×2
1

FIG. 5

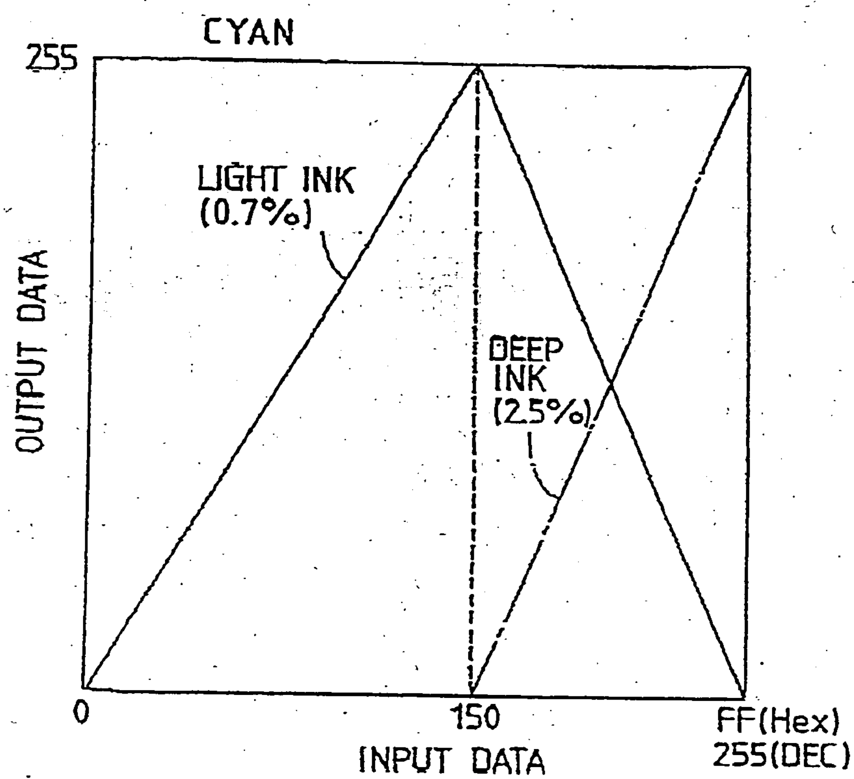

CYAN
255
LIGHT INK
(0.7%)
DEEP
INK
(2.5%)
OUTPUT DATA
0
150
FF(Hex)
255(DEC)
INPUT DATA

FIG. 7

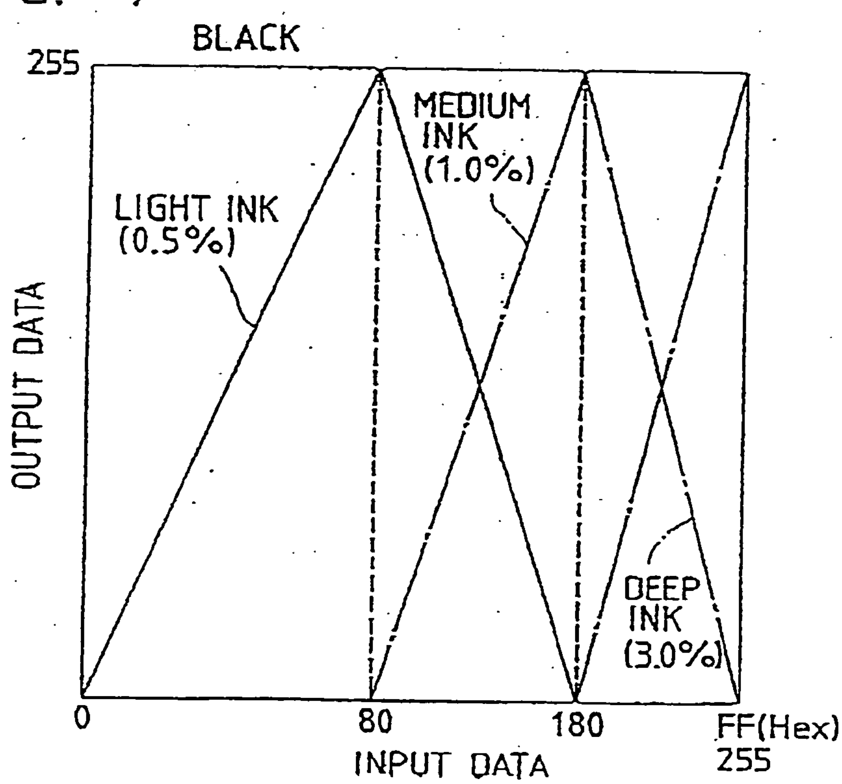

BLACK
255
MEDIUM
INK
(1.0%)
LIGHT INK
(0.5%)
DEEP
INK
(3.0%)
OUTPUT DATA
0
80
180
FF(Hex)
255
INPUT DATA

FIG. 8A

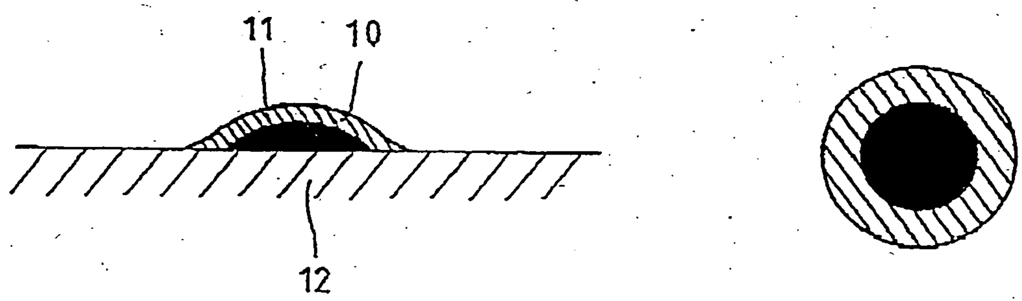


FIG. 8B

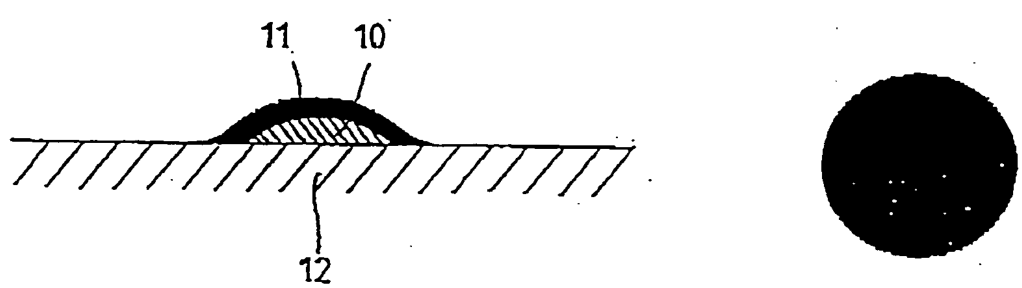


FIG. 9

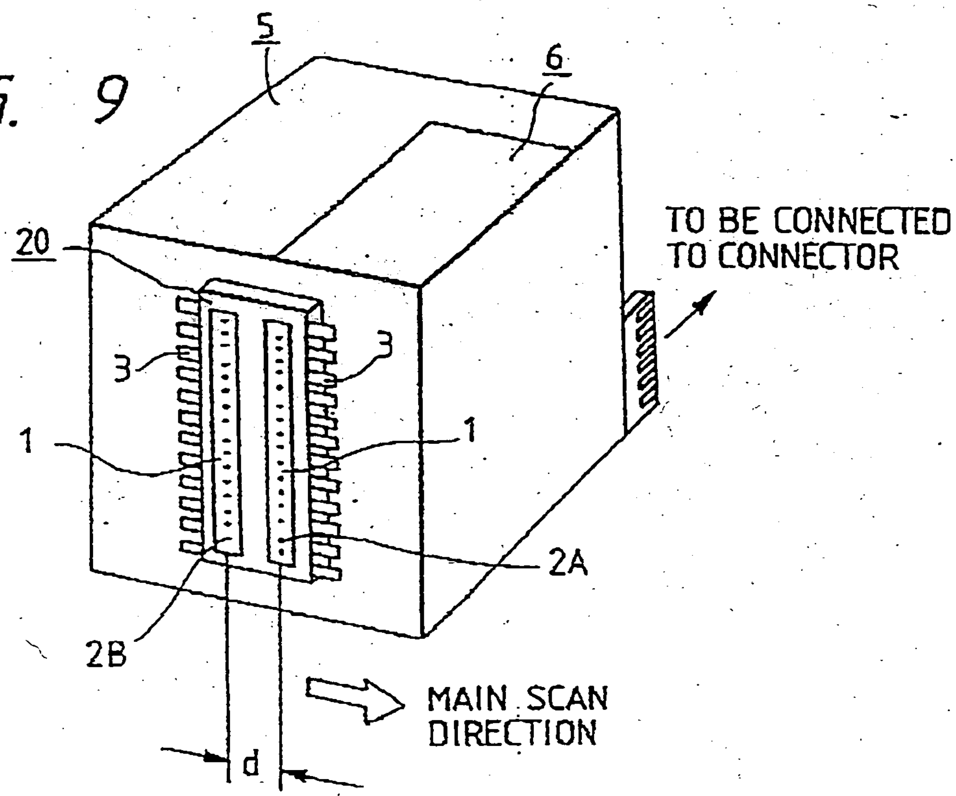

5
6
20
3
3
1
1
2A
2B
TO BE CONNECTED
TO CONNECTOR
MAIN SCAN
DIRECTION
d

FIG. 10

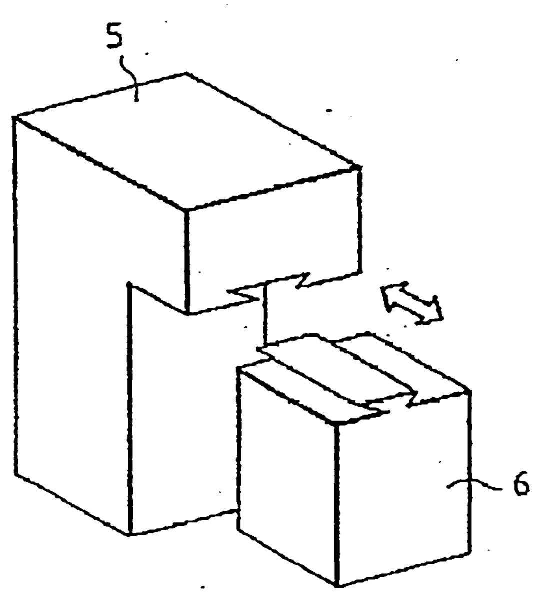

5
6

FIG. 11

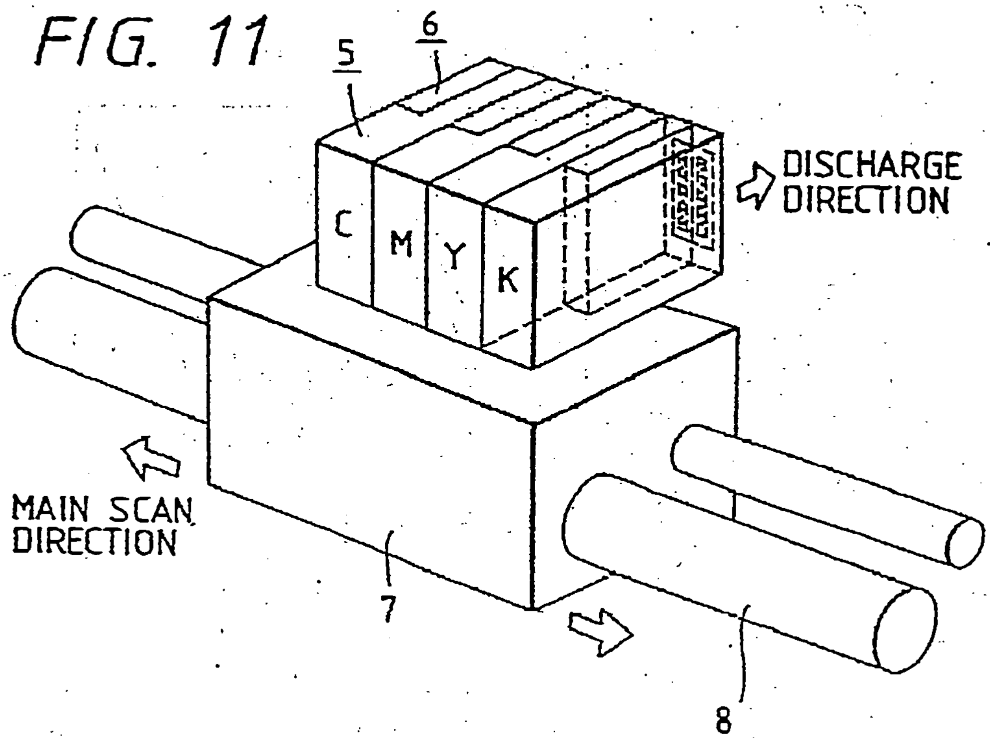

6
5
C
M
Y
K
DISCHARGE DIRECTION
MAIN SCAN DIRECTION
7
8

FIG. 13

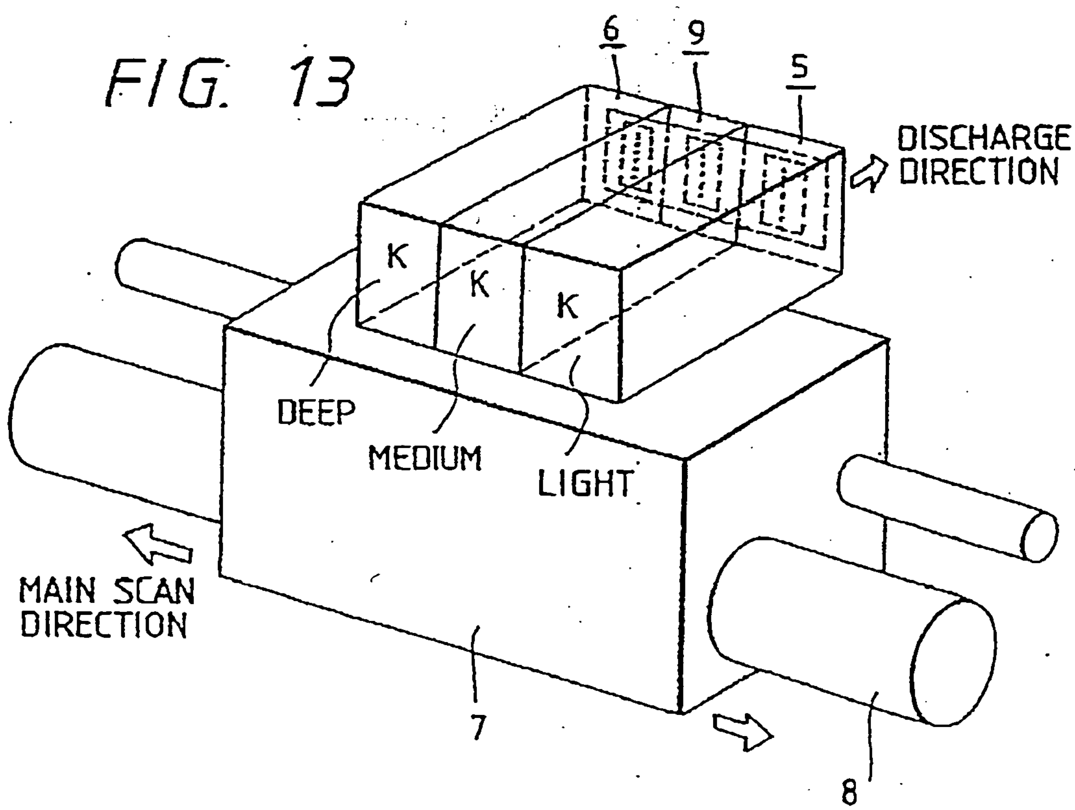

6
9
5
K
K
K
DISCHARGE DIRECTION
DEEP
MEDIUM
LIGHT
MAIN SCAN DIRECTION
7
8

FIG. 12

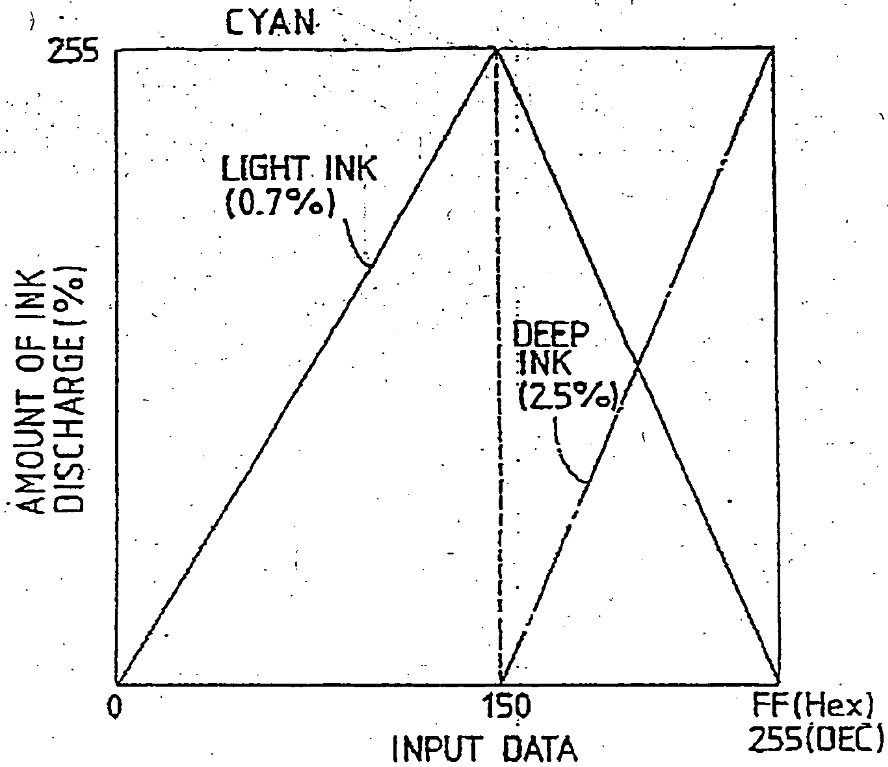
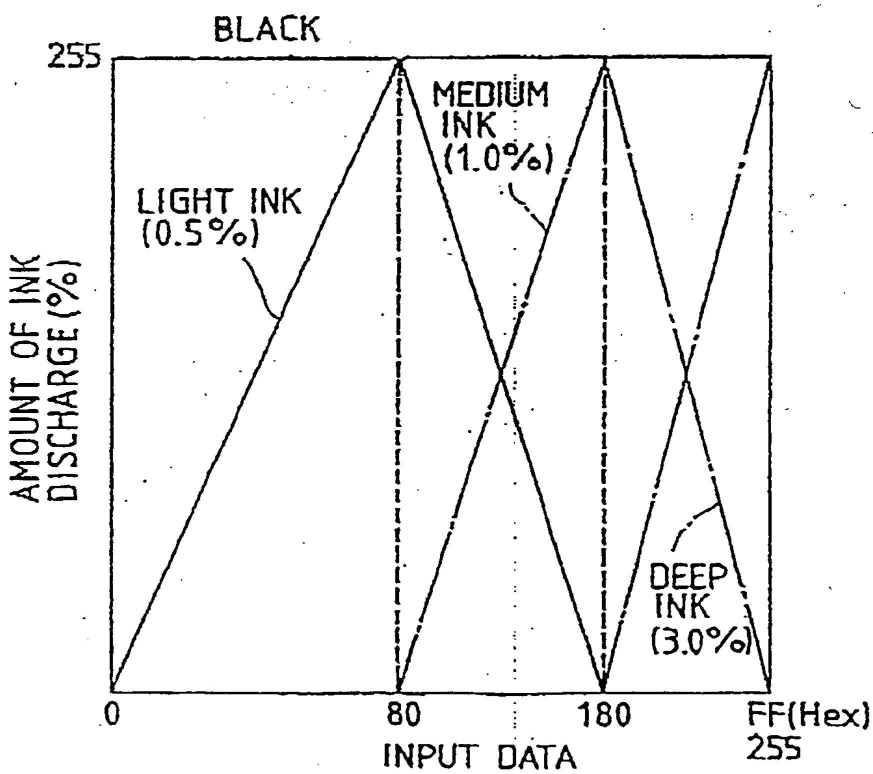

CYAN
255
LIGHT INK
(0.7%)
DEEP
INK
(2.5%)
AMOUNT OF INK
DISCHARGE (%)
0
150
FF(Hex)
255(DEC)
INPUT DATA

FIG. 14


BLACK
255
MEDIUM
INK
(1.0%)
LIGHT INK
(0.5%)
DEEP
INK
(3.0%)
AMOUNT OF INK
DISCHARGE (%)
0
80
180
FF(Hex)
255
INPUT DATA

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